EFFECT OF BUBBLE GENERATING DEVICES ON RECOVERY OF CLEAN COAL FROM REFUSE USING COLUMN FLOTATION

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ABSTRACT
Column flotation testing was conducted on the flotation feed slurry obtained from a preparation plant located in the southern Illinois coal basin using three different bubble generating devices, static sparger, gas saver and foam jet. Each of these devices were tested with three different types of frother and various column operating variables to provide maximum combustible recovery, minimum product ash and maximum pyrite rejection. Alcohol frothers were most effective for use with the static sparger, somewhat less effective for the foam jet and ineffective for the gas saver. Glycol frothers were effective for all three bubble generating systems, providing high combustible recovery (>90 percent), low clean coal ash (4-6 percent ash) and high pyrite rejection (70-80 percent).

INTRODUCTION
Cleaning of fine coal to a very low mineral matter content would have a significant impact on the marketability of high sulfur coals. Most coal preparation plants discard the fine (-28 mesh) coal due to currently available inefficient and uneconomical conventional flotation processes. These fine size refuse slurries are excellent feedstocks for producing low ash, low pyritic sulfur clean coal because the major amount of impurities are liberated.

The column flotation technique has received attention for its ability to provide clean coal containing low mineral matter at high combustible recovery. Yoon,[1] Yang[2] and Christophersen[3] have reported success in removal of high amounts of mineral matter from various fine coals. Parekh et al.[4,5] have reported that using their 'Ken-Flote' column, up to 95 percent of pyritic sulfur was rejected from the Upper Freeport coal at 90 percent combustible recovery.

EXPERIMENTAL PROCEDURES
Samples of the froth flotation feed were collected from the Kerr-McGee Galatia preparation plant in plastic 55-gallon drums. Representative samples of the slurry were analyzed for percent solids, size distribution and proximate analysis. Baseline flotation tests were conducted using a Denver Model D-12 laboratory flotation machine to determine optimum reagent dosages.

For the column flotation studies, a 5 cm (2-inch) ID, 6 m (20-ft.) tall 'Ken-Flote' column was used (Figure 1). A description of the column has been reported elsewhere.[4,5] Figure 2 shows schematics of the three different types of bubble generating devices tested in this slurry. The static sparger was mounted inside the column and required only the addition of air at 0.276 KPa (40 psig). The gas saver was mounted externally and a mixture of air and reagentized water was forced through it. The 'foam jet' was mounted internally, and a mixture of air and reagentized water was forced through a porous metal plug to generate air bubbles.

The three different types of frothers used in the study and their suppliers were:
MIBC: Straight chain alcohol (Shell Oil Co.)
AF76: Mixed alcohols (American Cyanamid Co.)
M150: Glycol-based (Betz Chemical Co.)

RESULTS AND DISCUSSION
The particle size and ash analyses of the Galatia flotation feed are summarized in Table 1. The slurry contained 3.5 percent solids with an average particle size of 21.4 microns and had 41.72% ash.

Baseline flotation data obtained using the Denver flotation machine identified optimum fuel oil dosage to be 0.67 Kg/t (1.5 lb/t), while frother dosage was determined to be 0.33 Kg/t (0.75 lb/t) for each of the three frothers tested. With these dosages, combustible recovery ranged from 82 to 87 percent for the three frothers while the clean coal ash content ranged from 12.2 to 15.6 percent.

Column Flotation Tests

The column operating parameters that were varied were washwater rate, airflow rate and the type of bubble generating system used. Tables 2, 3 and 4 summarize the best results obtained for each of the frothers tested. These results were derived from a number of tests conducted using statistical design experiments.

The results obtained using MIBC and the three bubble generating devices are summarized in Table 2. The static sparger provided 91.4 percent combustible recovery, 5.97 percent clean coal ash and 66.8 percent pyrite rejection when 0.2 L/min washwater and 1.0 L/min airflow were used. Pyrite rejection improved to 76.3 percent when the foam jet was used for bubble generation, however, combustible recovery decreased to 88.4 percent while clean coal ash improved to 5.10 percent ash. MIBC was not suitable for use with the gas saver (64.9 percent combustible recovery and 3.66 percent clean coal ash).

Results obtained with AF76 are summarized in Table 3. When the static sparger was used with 1 L/min airflow and 0.6 L/min washwater, combustible recovery was 89.9 percent with 5.25 clean coal ash and 75.8 percent pyrite rejection. The foam jet provided slightly higher combustible recovery (91.3 percent) with similar clean coal ash (5.20 percent ash) and pyrite rejection (75.5 percent). Optimum airflow requirement for the foam jet with AF76 was 3 L/min while optimum washwater was 0.2 L/min. As with MIBC, AF76 was not a suitable frother for use with the gas saver providing only 47.2 percent combustible recovery.

All the bubble generating devices provided excellent flotation results with M150 frother as shown in Table 4. The static sparger provided 88.6 percent combustible recovery, 6.21 percent clean coal ash and 64.8 percent pyrite rejection. With the gas saver, combustible recovery improved to 91.0 percent, clean coal ash was reduced to 5.68 percent and pyrite rejection improved to 72.5 percent. The best results were obtained with the foam jet which provided 90.1 percent combustible recovery, 4.80 percent ash in the clean coal and 76.9 percent pyrite rejection.

CONCLUSIONS

Based on the experimental data presented, it can be concluded for the Galatia flotation feed that:

- Column flotation provided lower ash (4 to 8%) clean coal product at 90 percent combustible recovery with the three frothers used.
- Column flotation also rejected 50-80 percent pyrite depending on the column operating parameters and the type of frother used. The best results were obtained with the foam jet and M150 frother combination, where 77 percent pyrite rejection was achieved while maintaining 90 percent combustible recovery.
- M150 was an effective frother for all the three bubble generating systems tested, providing high (>90 percent) combustible recovery and low (4-6 percent) clean coal ash content.

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Table 1. Analysis of Kerr-McGee Galatia Flotation Feed

SIZE FRACTION (Mesh)	WEIGHT PERCENT	PERCENT ASH	ASH DISTRIBUTION (Percent)
+200	15.2	7.00	2.5
-200+325	9.4	13.10	2.9
-325+500	8.4	17.45	3.5
-500	67.0	56.66	91.1
Calc Feed	100.0	(41.72)	100.0

Table 2. Optimum Results Obtained with Column Flotation of the Galatia Slurry Using MIBC Frother

BUBBLE GENARATOR	AIRFLOW (lpm)	WASHWATER (lpm)	COMBUSTIBLE RECOVERY %	CLEAN COAL ASH %	PYRITE REJECTION %
SPARGER	1.0	0.2	91.4	5.97	66.8
GAS SAVER	2.0	0.2	64.9	3.66	ND
FOAM JET	1.0	0.2	88.4	5.10	76.3

Table 3. Optimum Results Obtained with Column Flotation of the Galatia Slurry Using AF76 Frother

BUBBLE GENARATOR	AIRFLOW (lpm)	WASHWATER (lpm)	COMBUSTIBLE RECOVERY %	CLEAN COAL ASH %	PYRITE REJECTION %
SPARGER	1.0	0.6	89.9	5.25	75.8
GAS SAVER	2.0	0.2	47.2	3.32	ND
FOAM JET	3.0	0.2	91.3	5.20	75.5

Table 4. Optimum Results Obtained with Column Flotation of the Galatia Slurry Using M150 frother

BUBBLE GENARATOR	AIRFLOW (lpm)	WASHWATER (lpm)	COMBUSTIBLE RECOVERY %	CLEAN COAL ASH %	PYRITE REJECTION %
SPARGER	1.0	0.2	88.8	6.21	64.8
GAS SAVER	1.0	0.2	91.0	5.68	72.5
FOAM JET	2.0	0.4	90.0	4.80	78.9

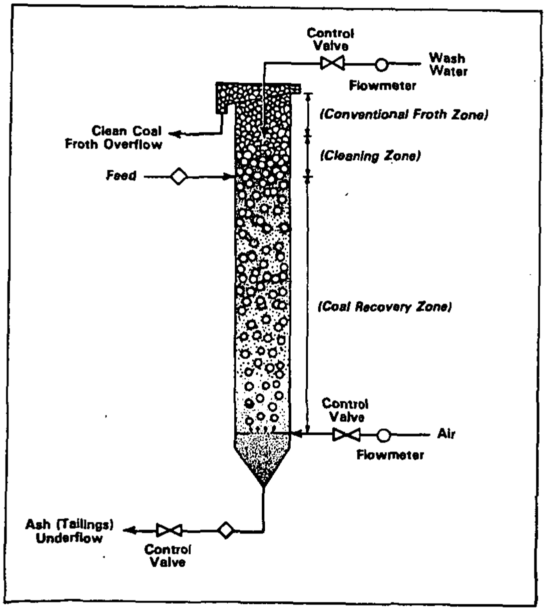

Figure 1. Line Diagram of the 'Ken-Flote' Column Flotation Cell.

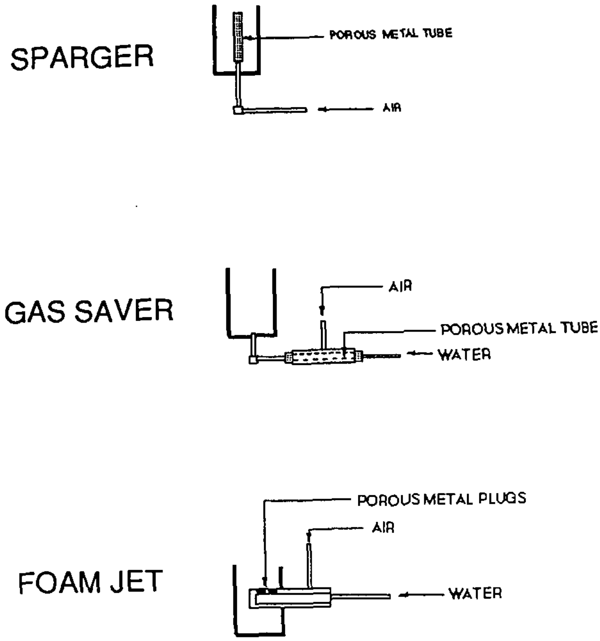

Figure 2. Diagrams of the Three Bubble-Generating Devices Utilized in Column Flotation Testing.